The Geological Heritage of Cavan

An audit of County Geological Sites in Cavan

by Matthew Parkes, Robert Meehan, Vincent Gallagher and Sarah Gatley

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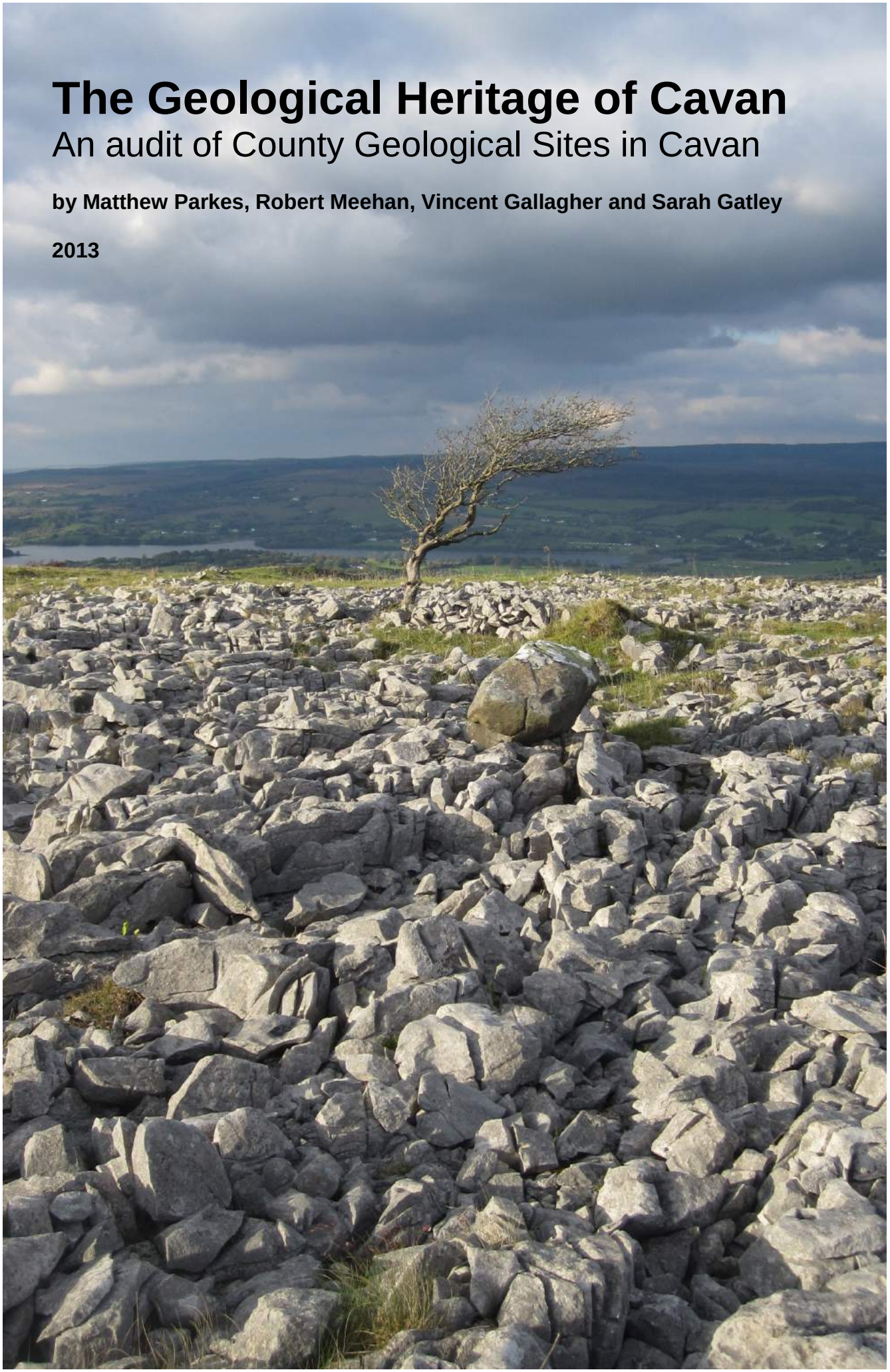

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An Chomhairle Oidhreachta
The Heritage Council

GSI
Suirbhéireacht Gheolaíochta Éireann
Geological Survey of Ireland

CAVAN HERITAGE
CAVAN COUNTY COUNCIL

Fearðhacht is firinne

**This report is an action of the
County Cavan Heritage Plan 2006 – 2011**

For the:
Irish Geological Heritage Programme
Geological Survey of Ireland
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Report Summary

County Cavan is recognised both within the county and in the national and international community for its superb geological heritage. The County Council's support for the World's first cross-border Geopark, encompassing the Cuilcagh area and the Marble Arch Caves in County Fermanagh, has been critical in raising the profile of geological heritage in Cavan. The geology of the county is quite diverse and the geological heritage interest extends throughout the county, not just within the Geopark area.

This report documents what are currently understood by the Irish Geological Heritage Programme (IGH) of the Geological Survey of Ireland (GSI) to be the most important geological sites within Cavan. It proposes them as County Geological Sites (CGS), for inclusion within the Cavan County Development Plan (CDP). The audit provides a reliable study of sites to replace a provisional listing based on desk study which was adopted in a previous CDP.

County Geological Sites do not receive statutory protection like Natural Heritage Areas (NHA) but receive an effective protection from their inclusion in the planning system. However, some of the sites described in this report are considered to be of national importance as best representative examples of particular geological formations or features. They have been provisionally notified to the National Parks and Wildlife Service (NPWS) by the GSI for designation as NHAs (Natural Heritage Areas), after due survey and consultation with landowners. However, many of these sites fall within existing pNHAs and SACs where the ecological interest is founded upon the underlying geodiversity. The commission of this audit and adoption of the sites within the County Development Plan ensure that County Cavan follows a now established and effective methodology for ensuring that geological heritage is not overlooked in the general absence of allocated resources for progress at national level. It ensures that Cavan remains at the forefront of geological conservation in Ireland, in parallel with the sustained development of the Marble Arch Caves Global Geopark .

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This report is written in non-technical language (with a glossary for unavoidable geological terminology) as a working document for use by the Heritage Officer and the Planning department of Cavan County Council. It will also be made available *via* the County Council website for the people of Cavan. A chapter of the report includes recommendations on how to best present and promote the geological heritage of Cavan to the people of the county. It will also inform the work of the IGH Programme and be made available through the GSI website.

The preliminary sections, summary geological history and accompanying map, timescale and stratigraphical column particularly may be used as they stand to preface a booklet or as website information in the development of this work, and for information as seen fit by the Heritage Officer. The contents also provide the essential ingredients for a public-oriented book on the geological heritage of Cavan, if funding can be sourced to produce it.

Cavan in the context of Irish Geological Heritage

This report ensures Cavan remains active at the forefront of geological heritage within Ireland, as it is one of around half of the counties to date to commission such an audit within the scope of the county-based Heritage Plan. It will hopefully encourage the remaining local authorities to follow what is now a tried and trusted methodology. In the absence of significant political and economic resources available at a national level to the relevant bodies for conservation of geological heritage as Natural Heritage Areas (NHA), it represents a significant level of progress in defining and safeguarding Ireland's geological heritage.

It also represents a significant commitment on the part of the Local Authority to fulfil its obligations to incorporate geology into the spectrum of responsibilities under the Heritage Act 1995, the Planning and Development Act 2000, Planning and Development Regulations 2001, and the Wildlife (Amendment) Act, 2000 and the National Heritage Plan (2002). GSI views partnerships with the local authorities, exemplified by this report, as a very important element of its strategy on geological heritage (see Appendix 1).

The Irish Geological Heritage Programme (IGH) in GSI complements other nature conservation efforts of the last decade, by assessing Ireland's geodiversity. Geodiversity is the foundation of the biodiversity addressed under European Directives on habitats and species by the designations of Special Areas of Conservation (SAC) and more recently on a national scale by the introduction of NHAs as the national nature conservation method. As a targeted conservation measure to protect the very best of Irish geology and geomorphology the IGH Programme fills a void which has existed since the abandonment of the Areas of Scientific Interest scheme, listed by An Foras Forbartha in 1981.

The IGH Programme fulfils this by identifying and selecting the most important geological sites nationally for designation as NHAs. It looks at the entire spectrum within Irish geology and geomorphology under 16 different themes:

IGH THEMES

1. Karst
2. Precambrian to Devonian Palaeontology
3. Carboniferous to Pliocene Palaeontology
4. Cambrian-Silurian
5. Precambrian
6. Mineralogy
7. Quaternary
8. Lower Carboniferous
9. Upper Carboniferous and Permian
10. Devonian
11. Igneous intrusions
12. Mesozoic and Cenozoic
13. Coastal geomorphology
14. Fluvial and lacustrine geomorphology
15. Economic geology
16. Hydrogeology

A fundamental approach is that only the minimum number of sites necessary to demonstrate the particular geological theme is selected. This means that the first criterion is to identify the best national representative example of each feature or major sequence, and the second is to identify any unique or exceptional sites. The third criterion, identification of any sites of International importance, is nearly always covered by the other two.

Designation of geological NHAs will be by the GSI's partners in the Programme, the National Parks and Wildlife Service (NPWS). Once designated, any geological NHAs will be subject to normal statutory process within the Cavan Planning Department and other relevant divisions. **However, compared to many ecological sites, management issues for geological sites are generally fewer and somewhat different in nature. The subsequent section considers these issues**.

From a national perspective, as a result of extensive comparison of similar sites to establish the best among them, there is now a good knowledge of many other sites which are not the chosen best example, but may still be of national importance. Others may be of more local importance or of particular value as educational sites or as a public amenity. All these various important sites are proposed for County Geological Site (CGS) listing in the County Development Plan, along with any clear NHA selections.

Currently, in 2013, a Master List of candidate CGS and NHA sites has been established in GSI with the help of Expert Panels for all the 16 IGH themes. For several themes, the entire process has been largely completed and detailed site reports and boundary surveys have been done along with a Theme Report. Due to various factors, they have not been formally designated yet, although only a very small number of sites (*e.g.* Cormeen Quarry and Moneycass Glebe) are considered to be of national importance and have been put forward as Natural Heritage Areas (NHA). Therefore, inclusion of all sites as County Geological Sites (CGS) in Cavan's planning system will ensure that they are not inadvertently damaged or destroyed through lack of awareness of them outside of the IGH Programme in GSI.

The sites proposed here as County Geological Sites (CGS) have been visited and assessed specifically for this project, and represent our current state of knowledge. It does not exclude other sites being identified later, or directly promoted by the Council itself, or by local communities wishing to draw attention to important sites for amenity or education with an intrinsic geological interest. New excavations, such as major road cuttings or new quarries, can themselves be significant and potential additions to this selection.

It was not possible within the scope of this study to identify landowners except in a few sites, but it is emphasised that listing here is not a statutory designation, and carries no specific implications or responsibilities for landowners. It is primarily a planning tool, designed to record the scientific importance of specific features, and to provide awareness of them in any decision on any proposed development that might affect them. It thus also has an educational role for the wider public in raising awareness of this often undervalued component of our shared natural heritage.

Geological conservation issues and site management

Since **geodiversity is the often forgotten foundation for much of the biodiversity** which has been identified for conservation through SAC or NHA designation, it is unsurprising that many of the most important geological sites are actually in the same areas as SAC and NHA sites. In these areas, the geological heritage enhances and cements the value of these sites for nature conservation, and requires no additional designation of actual land areas, other than citation of the geological interest.

Broadly speaking, there are two types of site identified by the IGH Programme. The first, and most common, includes small and discrete sites. These may be old quarries, natural exposures on hilly ground, coastal cliff sections, or other natural cuttings into the subsurface, such as Moneycass Glebe or Cormeen. They typically have a feature or features of specific interest such as fossils or minerals or they are a representative section of a particular stratigraphical sequence of rocks. **The second type of site is a larger area of geomorphological interest, *i.e.* a landscape that incorporates features that illustrate the processes that formed it**. The Quaternary theme and the Karst theme include such sites. In Cavan, the superb ribbed moraines are characteristic of the larger sites encompassed under the IGH 7 Quaternary theme. Large areas of Cavan's landscape are covered by such ribbed moraines or drumlins, which can present a problem for geoheritage as, although unique and impressive, they can be too extensive to consider as 'sites'.

It is also important from a geological conservation perspective that planners understand the landscape importance of geomorphological features which may not in themselves warrant any formal site designation, but which are an integral part of the character of Cavan. A lack of awareness in the past, has led to the loss of important geological sites and local character throughout the country. In Cavan a full Landscape Characterisation Assessment has not yet been completed but the Draft Cavan County Development Plan 2014–2020 has included some basic landscape characterisation and a series of policy objectives to support it. This provides a tool to help future planning decisions maintain the landscape character of the County.

There are large differences in the management requirements for geological sites in comparison to biological sites. Geological features are typically quite robust and generally few restrictions are required in order to protect the scientific interest. In some cases, paradoxically, the geological interest may even be served better by a development exposing more rock. **The important thing is that the relevant planning department is aware of the sites and, more generally, that consultation can take place if some development is proposed for a site**. In this way, geologists may get the opportunity to learn more about a site or area by recording and sample collection of temporary exposures, or to influence the design so that access to exposures of rock is maintained for the future, or occasionally, to prevent a completely inappropriate development through presentation of a strong scientific case.

In other counties, working quarries may have been listed because they are the best representative sections available of specific rock sequences, in areas where exposure is otherwise poor. No restriction is sought on the legitimate operation of these quarries. However, maintenance of exposure after quarry closure is generally sought in agreement with the operator and planning authority in such a case. At present, no working quarries are

included as County Geological Sites in Cavan, but these issues are briefly explored in a set of Geological Heritage Guidelines for the Extractive Industry, published jointly by the GSI and the Irish Concrete Federation in 2008.

A new quarry may open up a window into the rocks below and reveal significant or particularly interesting features such as pockets of fossils or minerals, or perhaps a karstic depression or cave. Equally a quarry that has finished working may become more relevant as a geological heritage site at that stage in its life. It may need regular maintenance to prevent overgrowth of vegetation obscuring the scientific interest, or may be promoted to the public by means of a viewing platform and information panel.

Nationally, specific sites may require restrictions and a typical case might be at an important fossil locality or a rare mineral locality, where a permit system may be required for genuine research, but the opportunity for general collecting may need to be controlled. However, Cavan's sites are not likely to require such an approach. It should be noted that within the European and Global Geopark Network, there are some self-imposed, self-regulated and quite restrictive rules relating to the collection and sale of geological specimens, which would apply to sites within the Marble Arch Caves Global Geopark area.

Waste dumping

An occasional problem throughout the country, including in County Cavan, is the dumping of rubbish in the countryside. The dumping of waste is not only unsightly and messy, but when waste materials are dumped in areas where rock is exposed, such as limestone quarries or karstic depressions, they may leach into the groundwater table as they degrade. This can cause groundwater pollution and can affect nearby drinking water supplies in wells or springs. Groundwater Protection Schemes (DELG 1999) help to combat pollution risks to groundwater by zoning the entire land surface within counties into different levels of groundwater vulnerability. Such a scheme was completed for Cavan County Council by the GSI in 2007, thus ranking the county land surface into vulnerability categories of 'Extreme', 'High', 'Moderate' and 'Low', and helping planners to assess which developments are suitable or not in certain areas of Cavan.

New exposures in development

One less obvious area where the Local Authority can play a key role in the promotion and protection of geology is in the case of new roads. **Wherever major new carriageways are to be built,** or in other major infrastructural work, it should be a policy within the Planning Department that **where new rock exposures are created, they be left open and exposed** unless geotechnical safety issues arise (such as where bedding dips are prone to rock failure). The grading and grassing over of slopes in cuttings is largely a civil engineering convenience and a mindset which is difficult to change. However, it leads to sterile and uninteresting roads that look the same throughout the country. Leaving rock outcrops exposed where they are intersected along the road, improves the character and interest of the route, by reflecting the geology and landscape of the locality. Sympathetic tree or shrub planting can still be done, but leaving bare rocks, especially where they show interesting features, not only assists the geological profession, but creates new local landmarks to replace those removed in the construction of the roadway. This can also potentially save money on the construction costs.

Geoparks

An extremely interesting development in geological heritage, not just in Europe but internationally, has been the rapid recent growth and adoption of the Geopark concept. A **Geopark is a territory** with a well-defined management structure in place (such as Local Authority support), **where the geological heritage is of outstanding significance and is used to develop sustainable tourism opportunities**. Initially it was largely a European Geoparks Network (EGN) but since 2004 has expanded worldwide as the Global Geoparks Network (GGN) and is fully assisted by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) [see www.globalgeopark.org and www.europeangeoparks.org]. A fundamental theoretical basis of the Geopark is that it is driven from the bottom up – the communities in the Geopark are the drivers of the project and are the main beneficiaries. The Geopark branding/concept therefore helps promote the geological heritage resource so that the community can benefit from it.

In Ireland there are three members of the Geoparks Network. One is the cross-border Marble Arch Caves Global Geopark in Cavan and Fermanagh [see www.marblearchcaves.net and www.cavancoco.ie/marble-arch-caves-global-geopark]. **The following section explores the importance of the Geopark and the relationship with Cavan County Council and partners in more detail, since it has very important implications for geological heritage within the county**. The Copper Coast Geopark in Waterford also joined the Network in 2001 [see www.coppercoastgeopark.com]. A recent addition has been the Burren and Cliffs of Moher in County Clare [see www.burrenconnect.ie/geopark]. In addition there are aspirant groups exploring the work and infrastructure required for applications in other areas such as Joyce Country in Mayo and Galway, and the Mourne Mountains, Slieve Gullion and Carlingford area. /? cross-border Mourne-Cooley-Gullion area.

Marble Arch Caves Global Geopark, Cavan County Council and the promotion of geological heritage in County Cavan

Cavan County Council has a long history of involvement with local communities and the development of tourism through the promotion of geological heritage in particular, and the landscape in general. In this section, this history is briefly summarised and an assessment of the relationship of County Council, Geopark and the community is offered.

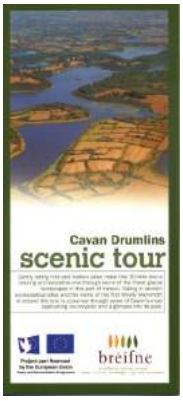
The 12 Counties Project: 'Landscapes from Stone'

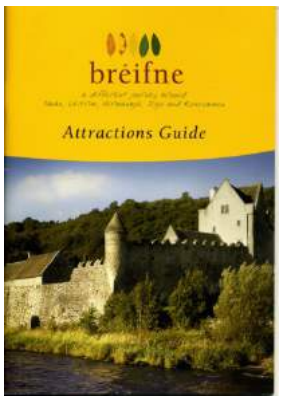
Arising from International Fund for Ireland and EU Special Peace & Reconciliation (SEUPB) funding at the end of the 1990's, GSI in partnership with the Geological Survey of Northern Ireland (GSNI) undertook various projects aimed at developing the scenic landscapes and rocks of the northern 12 counties of the island of Ireland into sustainable tourist attractions. It was decided that the best way to do this and bring geology to the general public would be to develop scenic drives and walks which would link sites of geological interest with established tourist attractions, visitor centres and sites of archaeological and mythological or folklore interest. The idea for "Landscapes from Stone" as a brand for general interest publications arose at this time. The twelve northern counties of the island are: Antrim, Armagh, Cavan, Derry, Donegal, Down, Fermanagh, Leitrim, Louth, Monaghan, Sligo and Tyrone. The European funding secured was supported by contributions from local authorities throughout the region, including County Cavan. A wide range of publications including walking and touring guides were produced under the banner of Landscapes from Stone. This project provided the foundations of much of the cross-border co-operation in geotourism and Geoparks between County Cavan and County Fermanagh which has been the hallmark of subsequent developments.

In the early 2000s a landscape tourism project, called the Breifne Mountains Project was led by the GSI and GSNI, and involved the county councils of Cavan, Fermanagh, Roscommon, Leitrim and Sligo along with Cavan Enterprise Board and the University of Ulster. It centred on the upland region of those counties that was once an ancient kingdom of Breifne. Funding was provided through an EU Peace and Reconciliation Programme [SEUPB]. The project aimed to develop a recognised brand name for this relatively little visited region of the island of Ireland and to promote tourism through highlighting elements of the geological landscape in an accessible way.

In brief, a wide range of printed guides, music and film DVDs, signage and a website were developed, created and installed. Sadly, due to an end to the project funding, and subsequent economic downturn, key continuing elements such as the Breifne tourism website hosted by Cavan County Council have since become inactive (although the GSI continues to host some data). In part, some functions have been superceded by the successful growth of the Marble Arch Caves Global Geopark, the first trans-national

Geopark in the world. Available resources in Cavan County Council for geotourism infrastructure are now directed into the Geopark.





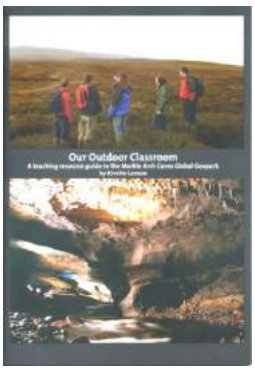
Marble Arch Caves Global Geopark

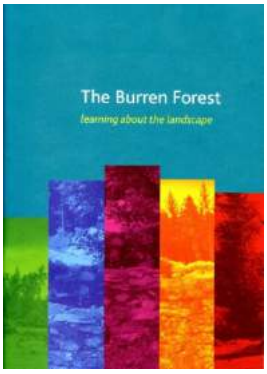
The Marble Arch Caves in County Fermanagh were opened to the public by Fermanagh District Council in 1985. In 1998 an expanded area was designated as the Cuilcagh Mountain Park. In 2001 the Marble Arch Caves were granted membership of the European Geoparks Network, the first in Northern Ireland and one of only 12 in Europe at that time.

In 2004 the Global Geoparks Network was established with a swathe of Chinese Geoparks joining with the European Geoparks Network, and receiving assistance from UNESCO. In 2007, the Marble Arch Caves Geopark was expanded by roughly ten times its original size to incorporate many uplands areas in Fermanagh to the north of the caves. This was followed in 2008 by the proposal, in partnership with Cavan County Council, to expand the Geopark across the border with the Republic of Ireland, which was successful in September 2008.

Since 2008, there has generally been a very successful and significant growth in the Geopark, with a very wide offering of events and activities for everyone from primary school children to mature adults. A high level of community participation and involvement is demonstrated by the range of different communities and partner organisations that can be listed from past annual programmes of events. In Cavan, a Geologist has been employed for most of the time since 2008 to run events, co-ordinate activities and develop educational programmes, primarily through the critical financial and technical support of the Geological Survey of Ireland.

Numerous publications have been produced as part of the Geopark's output. Two in particular are noted here. Kirstin Lemon produced a very valuable guide to sites within the Geopark, called 'Our Outdoor Classroom', aimed at teachers of post primary students, and linking what can be seen and demonstrated, to the school curricula in both Northern Ireland and the Republic of Ireland. For one site in particular, the Burren Forest, a colour workbook type guide entitled 'The Burren Forest - Learning about the landscape' is aimed at a generally younger student group or families. A recently published colour guide to the Geopark is worthy of wider distribution.





The Geopark within Cavan extends from the Cuilcagh area to encompass much of the western part of the county as far east as Cavan town. Programmes of signage, and site infrastructure works have continued and the Geopark is apparently thriving. There is obviously a high degree of 'buy-in' from the local community, as indicated by the sites where permissive access is possible such as Tullydermot Falls, Pollnaowen or Shannon Pot.

The investment of resources has been considerable, and is demonstrated further by the construction (Autumn 2013) of an unmanned visitor centre within the Burren Forest, and the opening up of the park to visitors with interpretation and signage. Of particular note in relation to the West Cuilcagh site and the White Father's Caves within it, has been the commissioning of a Conservation Plan for the caves by Cavan County Council. This site is a popular and accessible caving venue used by individual cavers and by organised outdoor pursuits centre groups. It has been the subject of various problems over recent years, and the Conservation Plan is a most welcome engagement by the County Council. Hopefully implementation of the plan will reduce or eliminate any future difficulties.

Many sites are used in educational activities or are highlighted by Geopark information signs, but many of these are viewpoints where panels show the underlying story of the landscape seen from that point. These have not been treated as County Geological Sites, and are simply good infrastructure for the Geopark visitors. Some sites have been noted which could be delineated with a boundary and a site report (individually or as a highlight within a large site) but have not been. An example is Pollnagossan within the Western Cuilcagh site. This pothole is in an enclosed depression beside the road, and has a Geopark sign identifying it at the roadside. The cave is a difficult pothole requiring particular skills and a site report might be considered as an encouragement to visitors to seek out such a site which is unsuitable and potentially dangerous.
However, in a cautionary note, despite the generally positive impact of the Geopark, it is worth observing that the Geopark concept is not universally understood. As a single example, but not as a scientific sample, one discussion with a landowner, near Garvagh Lough, who was interested and observant about the land around him, established/affirmed that the Geopark idea meant only the Marble Arch Caves to him, and he was unfamiliar with the philosophy and principles behind Geoparks. Even in sight of the Burren Forest and Garvagh Lough, some of the Geopark's communication efforts have not been entirely successful. It is to be hoped that continued work will deepen and broaden the public understanding of the Geopark.

Proposals and ideas for promotion of geological heritage in Cavan

The inclusion of geological heritage in the County Cavan Heritage Plan 2006-2011 as a component of natural heritage is a most welcome and positive step, for a topic that is often undervalued and poorly known in the wider community. This section examines the existing points in the plan where they can be related to geological heritage and provides specific suggestions as to how these may be implemented, supported or enhanced by the audit of geological heritage sites in the county. Many of the objectives and actions in the Heritage Plan for County Cavan are broad in scope and the audit may contribute to many aspirations relating to communicating and raising awareness of the heritage in Cavan.

In more specific terms:

Objective 1 Baseline data will be collected on the natural, built and cultural heritage of County Cavan

1.2 Following an audit of all information on natural heritage in County Cavan, establish gaps in existing data. Conduct surveys within the county which will address these gaps.

Audit Action: This audit will provide appropriate information and close the gap in existing data on geological heritage, both supplementing and complementing data collated in the Marble Arch Caves Geopark.

Objective 2 Heritage baseline data will be disseminated to Statutory, Community & Voluntary Sectors

2.6 Information collated on our rich cultural heritage will be made available on the heritage website and will be made accessible to local branch libraries, local schools, the community & voluntary sectors

Audit Action: This action can be partially fulfilled by adding the audit report to the County Council's website section on heritage, as well as to the Geological Survey of Ireland's website. In addition the audit may provide the material for a more 'public friendly' book.

Objective 3 A strategic management plan will be developed in order to safeguard the natural, built and cultural heritage of County Cavan

3.3 Natural and geomorphologic heritage sites of importance at a county level will be included into all County Development Plans, Town Development Plans and Local Area Plans

Audit Action: This action will be fulfilled in relation to geological heritage when the CGS shapefiles and associated data are included as a layer in the GIS of the Planning Section.

Objective 4 The natural, built and cultural heritage of County Cavan will be nurtured and enhanced through the implementation of programmes and initiatives as appropriate

4.5 The possibility of utilising our natural, built and cultural heritage in a positive manner to develop sustainable heritage amenities i.e. walking trails, cycling routes, greenways and ecological parks etc will be investigated

Audit Action: Geological heritage data from the audit may contribute to the development of many public amenities to support this action.

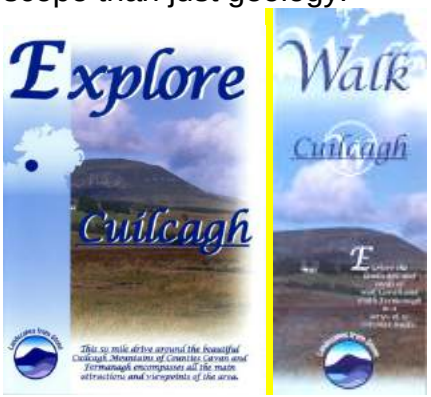
Other audit benefits:

Selected geological and speleological titles will be made available digitally to help build the county's heritage database. These titles will come from the authors' own resources and connections (including from Matthew Parkes, the Speleological Union of Ireland Librarian).

Specific ideas for projects

Leaflets

A project called 'Landscapes from Stone', run jointly between the GSI and the GSNI produced a series of walking and driving guides as leaflets in the year 2000. For Cavan, *Explore Cuilcagh* and *Walk Cuilcagh* remain in print. This is non-technical and broader in scope than just geology.



A range of many different leaflets, guides and posters are available as downloadable documents on the Geopark website, and many of these have been made available as printed editions. It is not appropriate to review them here, but they can be viewed at www.marblearchcaves.net

Guides

There are few existing guides to the geology of County Cavan, apart from literature produced within the Marble Arch Caves Global Geopark. There is scope for guides at different levels of detail and accessibility to non-specialists. A wide range of leaflets, booklets, books and other media are all feasible, but the research and production of appropriate text and images is a difficult task to do well without appropriate experience, and adequate time and resources. **It is suggested that with only modest editing and reorganisation the content of this report would comprise a good general guide to the geological heritage of County Cavan, in a broadly similar style to those books produced for Sligo, Meath, Fingal, Waterford and Roscommon following audits.**

Signboards

It is apparent from audit fieldwork that there is a very strong and well developed approach to signage within the Geopark. The expansion of the Geopark means that most of the western half of Cavan is covered. A collection of well sited information boards, all well branded with the necessary Geopark information, but with a wide range of interesting text and images, are found strategically placed at publicly accessible sites, roadside viewpoints with parking places and in key locations.

Museum exhibitions

As a result of the work to produce this report, the material for a panel based exhibition has been largely compiled. With some extra research covering human dependence on geology and resources, an interesting exhibition can be put together for display in the Cavan Museum, Council offices or County Library branches. The model followed was that used for Carlow and for Dun Laoghaire-Rathdown. Images of these can be seen on the Geological Heritage/Exhibitions section of the GSI website [www.gsi.ie].

New media
There are increasing numbers of examples of new methods of promoting Earth Sciences, *via* mobile phone applications and other electronic media. Self-guiding apps on specific sites would be one of these, such as those produced by Ingenious Ireland for Dublin city geology and the recently launched app for tourists in the Burren and Cliffs of Moher Geopark. Plans for such products would require some considerable effort to produce and imaginative planning, with the sites being scattered across the county. A possible channel for this is the superb record of Ice Age Action on the Cavan landscape.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Wednesday, May 15th, 2013

Smart move Burren gets own mobile phone app

Earth Science Ireland Group and magazine [www.earthscienceireland.org]
The group Earth Science Ireland is an all-Ireland group promoting awareness of Earth sciences and supporting educational provision in the subject. A main vehicle for the efforts is the twice a year magazine *Earth Science Ireland* and this is distributed free to thousands of individuals, schools, museums, centres and organisations. The editors would welcome more material from the Republic of Ireland and on Cavan's geological heritage. It is anticipated by the authors of this report that they will contribute a summary article distilled from the audit report.

Geoschol website [www.geoschol.com]
Geoschol is an educational project, now essentially represented by a website, which was largely aimed at producing educational materials on geology for primary schools. A four page pdf summarising the geology and some highlights of Cavan is already part of the available material (see Appendix 7). Working links to the Heritage section of Cavan County Council's website, and to other heritage websites, should be established.

Geopark Research Archive
If the Geopark wanted to do something similar to that produced in the Burren and Cliffs of Moher Geopark, with downloadable (or links to) free access papers, then a lot of groundwork is already provided by the reference lists in this audit. Making available technical references of direct relevance to the Marble Arch Caves Geopark geology and geomorphology will assist many users and researchers into the future. Equally, it could be done as a county-wide Geological Heritage Research Archive.

A summary of the Geology of Cavan

1) Paragraph summary

Cavan has many rocks that represent the ocean floor of some 400 to 500 million years ago, when Ireland was essentially two halves that were widely separated. The ocean closed by plate tectonic movements over that time, and the rocks were squeezed into stacked slices that now occupy much of central Cavan. The Crossdoney Granite is small but results from the ocean closure and stitching together of all the slices. In the northwest of the county, Carboniferous (specifically Dinantian) age rocks from around 340-320 million years ago are thick limestones, overlain by thick sandstones, such as at Cuilcagh Mountain. The limestones are from tropical seas, with many animals now preserved as fossils, and the sandstones represent a filling of those shallow seas by deltas and rivers. A small portion of Cavan is composed of Permian and Triassic rocks, best seen in Monaghan, but which include gypsum deposits. The overall landscape is most affected by the last Ice Age which left thick deposits of glacial till as drumlins, often combined into mega ridges of ribbed moraine. Disrupted drainage patterns provide a legacy of lakelands interspersed amongst, and rivers winding tortuously within, the ribbed moraines and drumlins.

AGE (Million Years Ago)	*ERA*	*PERIOD*	*EVENTS IN CAVAN (non-italics)*	*IF THIS TIMESCALE WAS A DAY LONG ...*
2.6	Cenozoic	Quaternary	Several ice ages smothering Cavan, followed in the last 10,000 years by the spread of vegetation, growth of bogs and arrival of humans. Deposition of drumlins and ribbed moraines, and moulding of crag-and-tails.	The ice ages would begin 38 seconds before midnight
66		Tertiary	Erosion, especially of limestone. Caves, cavities and underground streams developing in the limestones between Ballyconnel and Belturbet.	The Tertiary period begins at 11.40 pm
145	Mesozoic	*Cretaceous*	*Erosion.* *No record of rocks of this age in Cavan.*	11.15 pm
201		*Jurassic*	*Uplift and erosion.* *No record of rocks of this age in Cavan.*	The age of the dinosaurs, starting at 10.55 pm
252		Triassic	Desert conditions on land. Sandstones and gypsums deposited east of Kingscourt Town.	10.42 pm
298	Palaeozoic	Permian		10.30 pm
359		Carboniferous	Land became submerged, limestones with some shales and sandstones deposited in tropical seas around Lough Sheelin, and throughout the northern half of County Cavan. Limestones remaining today are dominated by muddy limestones. Shale and sandstone dominate northwest of Swanlinbar.	A significant portion of Monaghan's current rocks (limestone and shale) deposited around 10.10 pm
419		Devonian	*Caledonian mountain building.* Granites intruded into the subsurface around Crossdoney and Bellananagh.	9.52 pm
443		Silurian	Shallow seas, following closure of the Iapetus Ocean. Slates, greywacke and shales deposited across the southern third of County Cavan.	Starts at 9.42 pm
485		Ordovician	Slates, siltstones and volcanic rocks form across much of the central portion of County Cavan, northeast and southwest of Cavan Town.	Begins at 9.28 pm
541		*Cambrian*	*Opening of the Iapetus Ocean.* *No record of rocks of this age in Cavan.*	Starts at 9.11 pm
2500	Proterozoic	*Precambrian*	*Some of Irelands oldest rocks deposited in Mayo and Sligo.*	Beginning 11.00 am
4000	Archaean		*Oldest known rocks on Earth.*	Beginning 3.00 am
4600			*Age of the Earth.*	Beginning 1 second after midnight

The Geological Timescale and County Cavan

2) Simple summary

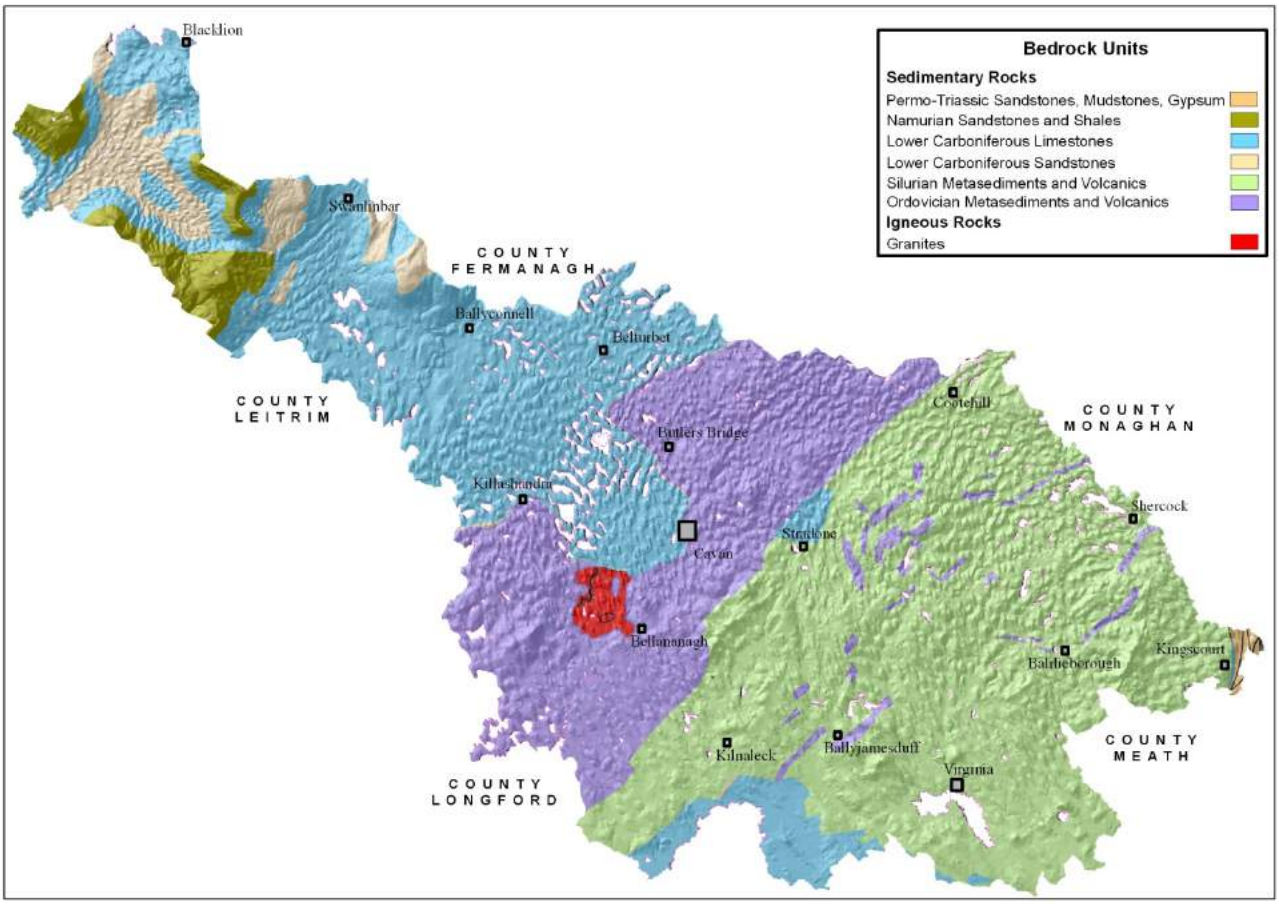
The oldest rocks in County Cavan are 417–495 million years old [Ma] mudstones and volcanic rocks. At that time Cavan lay beneath a deep ocean, on the edge of an ancient continent made up of Scotland, north America and the north of Ireland. A huge ocean separated this continent from the rest of Ireland, England, Wales and Europe. Over millions of years, plate tectonic movements closed this ocean and the two ancient continents collided, heating and deforming the ocean sediments to form slates and sandstones. The same rock types can be traced from Longford northeastwards through Cavan, County Down and into the Southern Uplands of Scotland. The ocean floor rocks were pushed up in a series of slivers against the northern side. County Cavan now has these slivers of slate and sandstones stacked up across the southern half of the county. Only where a few graptolite fossils occur in the black slates can we work out the actual age and stratigraphical sequence of the rocks.

As the ocean finally closed around 400 Ma bodies of molten magma moved up through the Earth's crust, cooling slowly to form granite. Just one small area of granite is known from the county, at Crossdoney a little southwest of Cavan town. The northern half of the county is composed of Carboniferous (specifically Dinantian) rocks, firstly limestones deposited in a shallow tropical sea containing abundant animal life. The sea then became shallower and was filled in by sediments that formed in river deltas and later solidified into sandstones and shales. These rocks occur in the uplands around Lough Allen and especially in the Cuilcagh Mountain area. In the area surrounding Cuilcagh Mountain, there is much exposed limestone that has developed karstic features since the last Ice Age, including many caves, potholes and limestone pavements.

In the succeeding Permian and Triassic periods Ireland lay in the northern tropics and the sedimentary rocks from this time are preserved around Kingscourt in Cavan, and also in Monaghan and Meath. They record deposition of sediments in arid deserts and temporary seas that periodically dried, precipitating thick evaporite deposits of gypsum. The subsequent Jurassic, Cretaceous, Tertiary (now officially termed the Paleogene and Neogene) periods have left no geological trace in Cavan, except a few residual weathering deposits. It is inferred that Ireland was mostly a land area, subject to weathering and erosion, which supplied only offshore basins with sediment.

Despite the influence that bedrock geology typically has on landscape, in Cavan the dominant control on formation of the landscape we see today was actually the movement of ice sheets that covered Cavan during the last Ice Age. The ice deposited ribbed moraines, crag-and-tails and drumlins that give the county its characteristic “basket-of-eggs” topography. Ribbed moraines are large ‘chains’ of drumlins, which are oriented transverse to ice flow. The name “drumlin”, used internationally, comes from the Irish 'dromnin' meaning 'low hill'. Drumlins are mounds of debris left behind by melting ice sheets and are typically streamlined in the direction of ice-sheet flow.

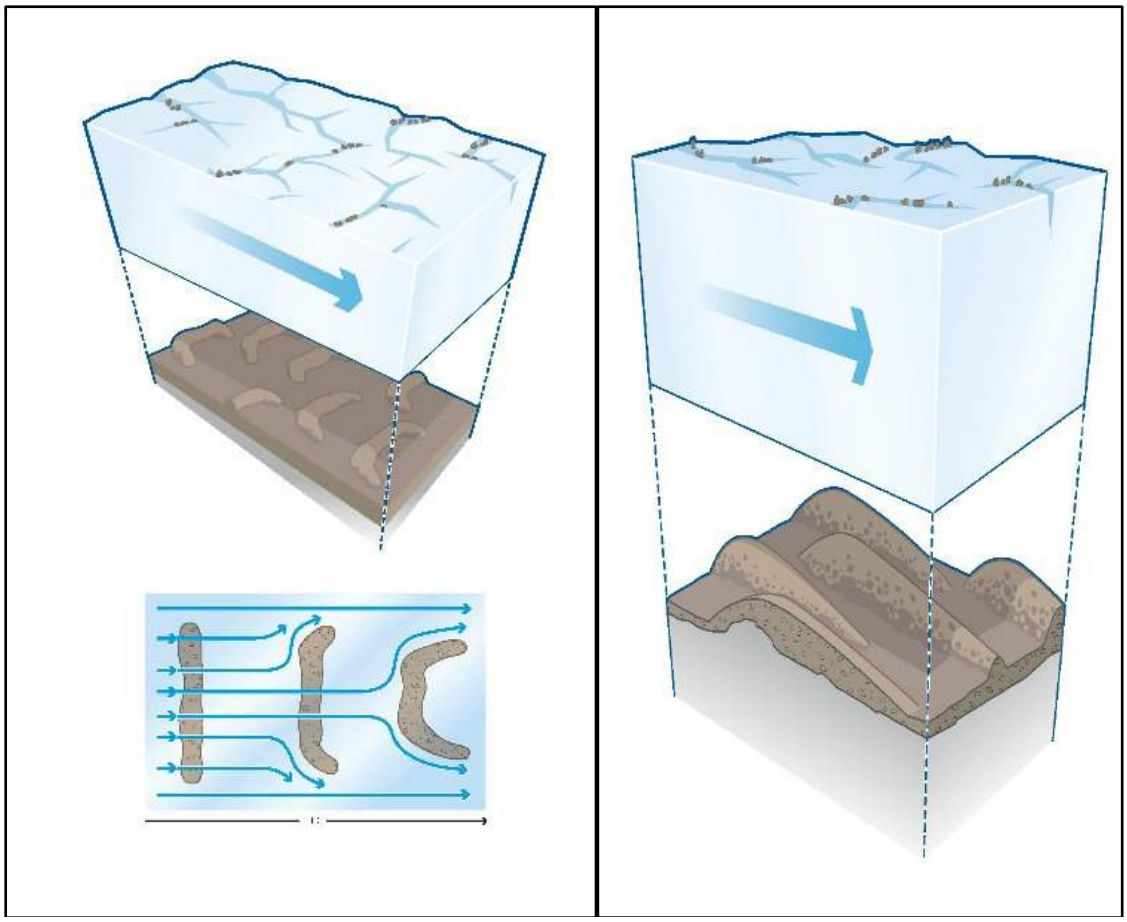
The ice sheet flowed generally northwest to southeast across Cavan, a fact illustrated by the orientations of the crag and tails and drumlins, which are aligned northwest to southeast in general. As well as this, erratics of Crossdoney granite have been carried southeastwards by the ice, and are found as far south as Sliene na Calliagh in northwest County Meath.



A simplified geology map of Cavan outlining the main bedrock geological units.

As the ice sheet melted, large lakes formed including Lough Sheelin-Kinale, which were joined as one lake at that time. At the edge of the lake large deltas were formed. Elsewhere in the county, deep meltwater channels were gouged out of the landscape by huge meltwater rivers. These are common on the eastern slopes of Cuilcagh. On the lowlands in the south of the county, the meltwater river of the Blackwater deposited massive volumes of sand and gravel as it flowed through the valley south of Lough Ramor.

Since the Ice Age, during the Holocene, the modern drainage pattern was superimposed on the deglacial channel network, meaning some areas of haphazard drainage among the drumlins and ribbed moraines. At this time peat also formed between the drumlin and ribbed moraine ridges.



Illustrations showing the formation of ribbed moraines (left) and drumlins (right) under a moving ice sheet.

Geological heritage versus geological hazards

Ireland is generally considered to be a country with very low risk of major geological hazards: there are no active volcanoes, Ireland's location on stable tectonic plates means that earthquakes are relatively rare and its recorded human history is not peppered with disastrous landslides, mudflows or other geological catastrophes. There are of course risks of one-off events, and this section briefly looks at the specific record and nature of geological hazards in Cavan and the relationship of the County Geological Sites to those hazards.

The difference between human timescales and geological timescales can be difficult to comprehend but for many geological processes there are periods of sudden activity encompassing major events, and then quiet periods in between. The sites in this audit represent evidence of past geological environments and processes, such as tropical coral seas, swampy deltas, glacier erosion of the land surface and so on. However, a few sites represent the active geomorphological or land-forming processes of today. These sites, generally coastal in many counties, but mainly karstic or riverine in Cavan, are dynamic environments and can be subject to constant or intermittent, sometimes sudden, change.

Landslides and bog flows

The Geological Survey of Ireland has been compiling national data on landslides in the past decade. Numerous landslides and bog slides have been recorded in Cavan, particularly in upland areas such as Cuilcagh. Over 60 landslide events are recorded in Cavan, mostly in the uplands of the northwest, and many have occurred in recent times or been well documented in the historic geological literature. The details for many of the older slides are quite sketchy as they are historical, unwitnessed or interpreted from ground scars.

Flooding

There are two types of flooding which need consideration.

River flooding occurs inland when the rainfall exceeds the capacity of the ground to absorb moisture and the river channels cannot adequately discharge it to the sea. The OPW website www.floods.ie can be consulted for details of individual flood events in County Cavan. Some 191 events are recorded across the entire county. Many of these are in urban settings where rainfall exceeds the capacity of the local drains, and many are recurring events at the same places.

Karstic flooding can occur when underground passages are unable to absorb high rainfall events. The limestone in northwest Cavan is heavily karstified and there is an abundance of caves, springs, swallow holes and dolines. Despite this, local flooding events have occurred and will occur when rainfall exceeds the capacity of the underground drainage system. Such underground drainage systems can fill up rapidly when rainfall is heavy or prolonged and there are many cave systems known to be dangerous to enter in unsettled weather. Caving fatalities have occurred in the past, from such events.

Karstic collapse

The presence of dolines in karstic areas such as west Cuilcagh, are clear evidence of the potential for new ones to form. These can be sudden events. However, the potential for such collapses is present in other limestone areas within the county.

Groundwater pollution

Whilst not such an obvious hazard as physical collapses, flooding and landslides, the pollution of groundwater supplies carries a serious risk to human health. Cavan is not one of the counties most dependent on groundwater supplies but the risk is serious for specific areas. As the groundwater is largely contained within limestone, it should be noted that karstic springs are especially vulnerable to pollution since the flow is mainly within fissure conduits that allow rapid transmission of pollution from source to water supply. The opportunity for microbial attenuation of pollutants is far less in limestone fissures (as there are no natural barriers to stop pollutants) than it would be in granular deposits, which act as natural filters.

Glossary of geological terms

Geological term	Definition
Adit	a horizontal or only gently inclined mine tunnel dug to access coal or mineral ore, or to drain, ventilate or further develop a mine.
Alluvial Deposit	unconsolidated clay, silt, sand and gravel, deposited by a body of running water.
Alluvium	a term for unconsolidated clay, silt, sand and gravel, deposited by a body of running water.
Aquifer	a water saturated rock unit.
Bedding Plane	the contact between individual beds of rock.
Bedrock	a general term for the rock, usually solid, that underlies soil or other unconsolidated, superficial material.
Biostratigraphy	using fossils to define the succession of rocks.
Blanket Bogs	bog covering a large, fairly horizontal area, which depends on high rainfall or high humidity, rather than local water sources for its supply of moisture.
Boulder Clay	unconsolidated, unsorted glacial deposits consisting of boulders and cobbles mixed with very finely ground-up rock or silt. Also known as till.
Brachiopods	a marine invertebrate of the phylum Brachiopoda - a type of shellfish. Ranging from Lower Cambrian to present.
Braided River	a river that consists of a network of small channels separated by small and often temporary islands.
Bryozoa	invertebrates belonging to the phylum Bryozoa, ranging from Ordovician to present, often found as frond-like, net-like or stick-like fossils.
Calcareous	containing significant calcium carbonate.
Calcite	a pale mineral composed of calcium carbonate, which reacts with dilute hydrochloric acid.
Carbonate	a rock (or mineral), most commonly limestone (calcite) and dolomite.
Cave	a natural underground space large enough for a human to enter, which is usually formed in either soluble limestone by karstic processes, or in exposed rock along the coastline, where the sea erodes natural rock fractures.
Clast	an individual constituent, grain or fragment of a sediment or rock, usually produced by mechanical weathering (disintegration) of a larger rock mass.
Cleavage	a finely spaced, flat plane of breakage caused by compressive deformation of rocks. e.g. the splitting of slate.
Clint	tabular block of limestone in a limestone pavement.
Crag and tail	a steep resistant rock mass (crag), with sloping softer sediments (tail) protected from glacial erosion or deposited as glacial debris on the crag's 'downstream' side.
Conglomerate	sedimentary rock comprising of large rounded fragments in a finer matrix.
Corrie	a horseshoe-shaped, steep-walled valley formed by glacial erosion.
Crinoid	a variety of sea-urchin, with a long flexible stem, usually anchored to the sea-floor and a body cup with arms which may be branching (a sea lily).
Cross-bedding	layering in sedimentary rocks at an inclined angle to bedding formed by current-ripples.
Crust	the outermost, solid, layer of the Earth.
Delta	a usually triangular alluvial deposit at the mouth of a river, or a similar deposit at the mouth of a tidal inlet, caused by tidal currents.
Dip/dipping	when sedimentary strata are not horizontal they are dipping in a direction and the angle between horizontal and the inclined plane is measured as the dip of the strata or beds.

Doline	circular/oval closed depression found in karst terrain.
Dolomite	calcium- and magnesium-bearing carbonate mineral; also a rock composed of the mineral.
Drumlin	a streamlined mound of glacial drift, rounded or elongated in the direction of the original flow of ice.
Epikarst	the shallow layer, near surface, of highly karstified rock, with many voids included.
Erratic	a rock fragment, often large, that has been transported, usually by ice, and deposited some distance from its source. It therefore generally differs from the underlying bedrock, the name "erratic" referring to the errant location of such boulders. Tracing their source can yield important information about glacial movements.
Facies	the character of the rock derived from its original sedimentary environment and process of deposition.
Fan	a usually triangular deposit of sand and gravel deposited by a glacial stream, either under a lake or under air.
Fault	planar fracture in rocks across which there has been some displacement or movement.
Fault Zone	a tabular volume containing many faults and fault rocks (rocks broken up by fault movement).
Fauna	collective term used to group all animal life.
Floodplain	a flat or nearly flat land area adjacent to a stream or river that experiences occasional or periodic flooding.
Flowstone	calcite or other minerals deposited as a surface crust by water flowing over cave or mine walls and floors.
Fluvial	pertaining to a river or stream.
Fold(ing)	flexure in layered rocks caused by compression.
Formation	a formal term for a sequence of related rock types differing significantly from adjacent sequences.
Fossiliferous	rich in fossils.
Fossils	any remains, trace or imprint of a plant or animal that has been preserved in the Earth's crust since some past geological or prehistorical time.
Glacial	of or relating to the presence and activities of ice or glaciers.
Grading	a sorting effect with the coarsest material at the base of the bed and finest grained material at the top.
Granite	a coarsely crystalline intrusive igneous rock composed mostly of quartz and feldspar.
Granodiorite	an igneous rock similar to granite but containing more of the mineral plagioclase and also more iron and magnesium-bearing minerals.
Greywacke	an impure sandstone, characterised by poorly-sorted, angular grains in a muddy matrix, that was deposited rapidly by turbidity currents (submarine avalanches).
Grike	a solutionally widened vertical fracture separating clints on a limestone pavement.
Gully	a deep valley created by running water eroding sharply into bedrock or subsoil.
Haematite	a mineral form of iron oxide, which is the main ore mined as iron.
Horizon	may refer to a single layer of rock such as a coal seam, an ash layer, or other geological 'event'.
Hummock	a small hill or knoll in the landscape, which may be formed by many different processes.
Ice margin	the edge of an ice sheet or glacier.
Igneous	a rock or mineral that solidified from molten or partially molten material i.e.

	from a magma.
Interglacial	the time interval between glacial stages, or pertaining to this time.
Joint	a fracture in a rock, which shows no evidence of displacement.
Karst	general term used for landscapes formed by weathering of soluble rocks, usually limestone, by surface water and/or groundwater.
Kettle hole	a shallow, sediment-filled body of water formed by retreating glaciers or draining floodwaters.
Knoll	a small hill or hillock sticking up from generally flat terrain.
Laminated	the finest example of stratification or bedding, typically exhibited by shales and fine-grained sandstones.
Limestone	a sedimentary rock consisting chiefly of calcium carbonate ($CaCO_3$), primarily in the form of the mineral calcite. It is mostly formed by the accumulation of calcareous shells, cemented by calcium carbonate precipitated from solution.
Lithification	the process of rock formation from unconsolidated sediment.
Lithology	the description of rocks on the basis of such characteristics as colour, composition and grain size.
Lodgement	process by which debris is released from the sliding base of a moving glacier/ice sheet and plastered or 'lodged' onto the glacier bed; also describes tills emplaced by this process (i.e. lodgement till).
Melt-out	process by which glacial debris is very slowly released from ice that is not sliding or deforming internally; also describes tills emplaced by this process (i.e. melt-out till).
Metamorphic	referring to the process of metamorphism or to the resulting metamorphic rock, transformed by heat and pressure from an originally igneous or sedimentary rock.
Misfit stream	a stream which is too small to have eroded the valley in which it flows, as is often the case with streams now flowing in meltwater channels.
Moraine	any glacially formed accumulation of unconsolidated debris, in glaciated regions, such as during an ice age.
Mudmound	Waulsortian limestone of Carboniferous age is characterised by forming as massive mounds or ridges or sheets of carbonate mud on the seafloor of the time. Mudmound is a general term to describe the varieties of forms.
Mudstone	a very fine grained sedimentary rock, containing quartz and clay minerals. Similar to shale, but not as easily split along the plane of bedding.
Ore	a mineral which is concentrated enough to be exploited by mining.
Orogeny	the creation of a mountain belt as a result of tectonic activity.
Outcrop	part of a geologic formation or structure that appears at the surface of the Earth.
Periglacial	very cold but non-glacial climatic conditions.
Phreatic	when a cave passage or void space in limestone rocks is filled with water it is said to be phreatic or in the phreas. When later found without water in them such passages have a characteristic cylindrical shape from solution in all directions and are called phreatic tubes.
Phreatic Zone	the area below the water table, where the rock is completely saturated with water.
Plate Tectonics	a theory that states that the crust is divided up into a number of plates, whose pattern of horizontal movement is controlled by the interaction of these plates at their boundaries with one another.
Pyrite	iron sulphide, pale yellow/gold coloured mineral, commonly occurring as cubes and often called 'fool's gold'.
Ribbed moraine	a subglacially (*i.e.* under a glacier or ice sheet) formed type of moraine landform that mainly occurs in Fennoscandia, Scotland, Ireland and Canada. They cover large areas that have been covered by ice, and occur

	mostly in what is believed to have been the central areas of the ice sheets.
Sandstone	a fine to coarse sedimentary rock, deposited by water or wind, and composed of fragments of sand (quartz grains), cemented together by quartz or other minerals.
Sandur	a plain formed of glacial sediments deposited by meltwater outwash at the terminus of a glacier.
Sedimentary	a rock formed by the deposition of sediment, or pertaining to the process of sedimentation.
Shaft	a vertical or inclined hole dug in a mine for access, ventilation, for hauling ore out or for pumping water out.
Shale	a very fine-grained mudstone, containing quartz and clay minerals, that splits easily along the plane of bedding.
Siltstone	is similar to mudstone but with a predominance of silt-sized (slightly coarser) particles.
Sink	another name for a swallow hole, the point where a stream passes underground.
Slumping	the movement of a mass of unconsolidated sediment or rock layers down a slope, or pertaining to contorted sedimentary bedding features.
Solution pipe	a karstic feature of solution in a vertical narrow chimney or pipe shape.
Spring	the point where an underground stream reaches the surface.
Stratigraphy	the study of stratified (layered) sedimentary and volcanic rocks, especially their sequence in time and correlation between localities.
Sub-aerial	refers to processes occurring above ground level, such as the weathering of rocks.
Subduction	the sinking of one crustal plate beneath the edge of another through the process of plate tectonics.
Subsidence (zone)	the sudden sinking or gradual downward settling of the Earth's surface with little or no horizontal movement.
Swallow hole	the point where a stream passes underground, sinking below the ground surface.
Terrestrial	pertaining to the Earth's dry land.
Till	unconsolidated, unsorted glacial deposits consisting of boulders and cobbles mixed with very finely ground-up rock as sand, silt or clay; also known as boulder clay.
Transgression	an incursion of the sea over land area.
Trilobites	extinct arthropods.
Turbidite	deposit of a turbidity current.
Turbidity Current	underwater density current carrying suspended sediment at high speed down a subaqueous slope. The resulting deposit is called a turbidite.
Turlough	a seasonal lake that fills and empties through springs and sinkholes.
Unconformable	a sedimentary rock that is not following in sequence from the one below but has a significant time gap present between them.
Unconformity	a buried erosion surface separating two rock masses or strata of different ages, indicating that sediment deposition was not continuous.
Vadose Zone	the area between the surface and the water table.
Vein quartz	white thin veins of quartz injected in rock fractures during episodes of stress. Also found as durable beach pebbles, once it has been eroded.
Volcanic Rock	any rock produced from volcanic material, e.g. ash, lava.
Volcaniclastic	rock material, derived from a volcanic eruption, re-deposited as a sedimentary rock, e.g. a sandstone, as an aggregate of small particles.
Volcanism	the process by which magma and its associated gasses rise into the crust and are extruded onto the Earth's surface and into the atmosphere.

Volcano	a vent in the surface of the Earth through which magma and associated gasses and ash erupt.

Data sources on the geology of County Cavan

This section is a brief summary of relevant GSI datasets, to assist any enquiry concerning geology and to target possible information easily. The GSI has very many datasets, accumulated since it began mapping Ireland's geology in 1845. A Document Management System (DMS) is freely available to any person at the GSI Customer Centre, into which about half a million documents and maps have been scanned. This means that any user can visit the GSI Customer Centre themselves and search on screen for data of relevance to them. High quality colour and black and white print-outs can be made or data supplied on CD, or *via* USB keys etc. **Data is available free of charge**. It is planned to make this resource available online but no date is yet set for when this may be achieved, although many subsets are already available within online data.

Key datasets include:

1:100,000 Map Report Series

All historical, modern and other mapping has been compiled into very useful maps and reports that describe the geology of the entire country. Parts of Sheets 7, 8/9, 12 and 13 include Cavan.

19th century 6 inch to the mile fieldsheets

These provide an important historical and current resource, with very detailed observations of the geology of the entire country.

19th century one inch maps and Memoirs

Information from the detailed 19th century mapping was distilled into one inch to the mile maps, of which parts of Sheets 44, 56, 57, 67, 68, 69, 79, 80 and 81 cover County Cavan. Each sheet or several sheets were accompanied by a Memoir which described the geology of that area in some detail. These still provide valuable records of observations even though interpretations may have changed with better geological understanding. Memoirs are in the Customer Centre library and scanned on the DMS.

Historical geological mapping is now available *via* a website:
http://www.geologicalmaps.net/irishhistmaps/history.cfm

Open File Data

Each Mineral Prospecting Licence issued by the Exploration and Mining Division of the Department of Communications, Energy and Natural Resources (currently) carries an obligation on the exploration company to lodge records of the work undertaken, for the common good. These records are held by the Geological Survey and are available as Open File Data, once a period of time has expired. They may include geological interpretations, borehole logs, geophysical and geochemical surveys and so on.

MinLocs Data

The MinLocs Database records all known mineral occurrences, however small, from GSI records, such as 19th century fieldsheets and Open File data.

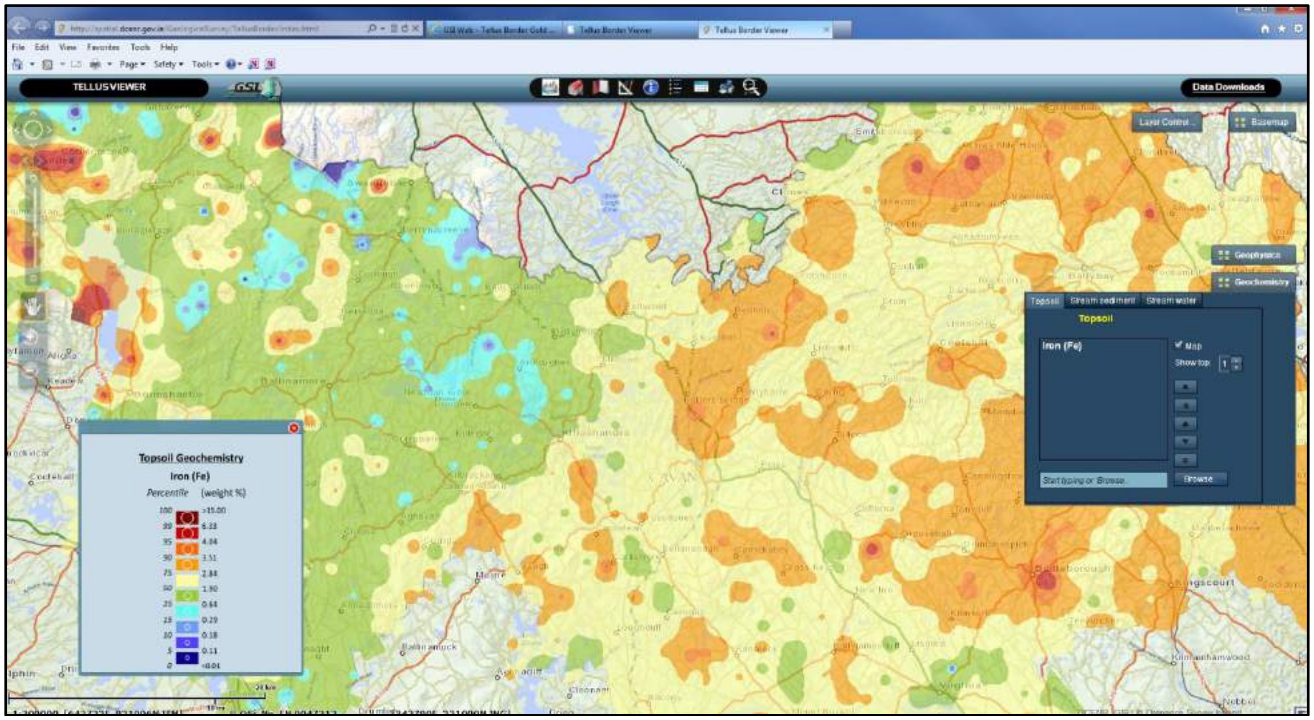
Historic Mine Records

Abandonment plans and various other material exists for the various mining ventures in the county, particularly in the gypsum mines of the Kingscourt - Carrickmacross district (mostly in Monaghan) and the iron mines of the Redhills district.

Subsoils Mapping
Since a Groundwater Protection Scheme has been completed (2007) for County Cavan by GSI, a recently completed map of the subsoil types and depths across Cavan exists, as well as the previously completed bedrock mapping. This provides a significant resource in general terms as well as for groundwater protection. Customised output is possible. Further more detailed compilation of glacial geology datasets, including a revision to be published by GSI in late-2013, will provide more options in the near future.

Digital mapping of many different datasets is now available via the GSI website: www.gsi.ie

Tellus Border Data
A very significant project undertaken over the last few years has been the Tellus Border project, in which enormous amounts of systematic data on geophysics and geochemistry of the border counties with Northern Ireland (including Cavan) has been gathered, extending the information gathered in Northern Ireland as part of the original Tellus Project. The GSI is one of 4 partners, and the project was funded under INTERREG IVA Programme. Airborne and ground based survey systematically gathered data on over 50 elements. This will have applications in environmental, health, mineral exploration and other areas. Public access to data from the project was launched on the 24th October 2013, and results will flow as analysis and research into the data proceeds. This project has its own website: www.tellusborder.eu



View of the TELLUS map of Iron concentrations in topsoil across County Cavan, as seen on the TELLUS map viewer at www.gsi.ie. See the high concentrations in northwestern Cavan and adjacent County Leitrim, where Slieve Anierin (Iron Mountain) is located.

Shortlist of Key Geological References

This reference list includes a few **key** papers, books and articles on the geology and geomorphology of Cavan that are recommended as access points to Cavan's fabulous geological heritage.

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Full Geological references

See Appendix 2 for the full reference list of all papers, books, articles and some unpublished reports etc relating to the geology and geomorphology of Cavan that could be traced.

Caving References

The references in Appendix 3 relate significantly to caves and caving within the Cavan area. They may only be brief reports or newsletter items. They are generally available within the Speleological Union of Ireland Library which is housed in the Geological Survey of Ireland and is managed by Matthew Parkes.

Mining heritage references

Appendix 2 includes some references specifically pertaining to the mining heritage of County Cavan. Assistance with locating these references may be provided by the Mining Heritage Trust of Ireland if required.

Quaternary References

The references in Appendix 4 are all covering the Quaternary, or Ice Age, geology of Cavan. They are split into the specific ones covering Cavan sites or features and a section of national or regional papers with some Cavan data included.

Further sources of information and contacts

Sarah Gatley of the Geological Survey of Ireland, who is the Head of the Geological Heritage and Planning Section, can be contacted in relation to any aspect of this report. Anne Marie Ward, the Heritage Officer of Cavan County Council, is the primary local contact for further information in relation to this report. Other contacts include the Conservation Rangers of the National Parks and Wildlife Service, currently in the Department of Arts, Heritage and the Gaeltacht. The names and phone numbers of current staff may be found in the phone book, or at www.npws.ie.

Web sites of interest

www.gsi.ie - for general geological resources
www.geology.ie – the website of the Irish Geological Association who run fieldtrips and lectures for members, including many amateur enthusiasts
www.earthscienceireland.org - for general geological information of wide interest [this website address is likely to change in 2012/2013. Suggestion search for 'Earth Science Ireland']
http://www.iqua.ie - for information, fieldtrips, lectures etc in relation to Ireland's Ice Age history
http://www.cavingireland.org/ - for information on caves and safe caving
http://www.progeo.se/ - for information about ProGEO the European Association for the Conservation of Geological Heritage

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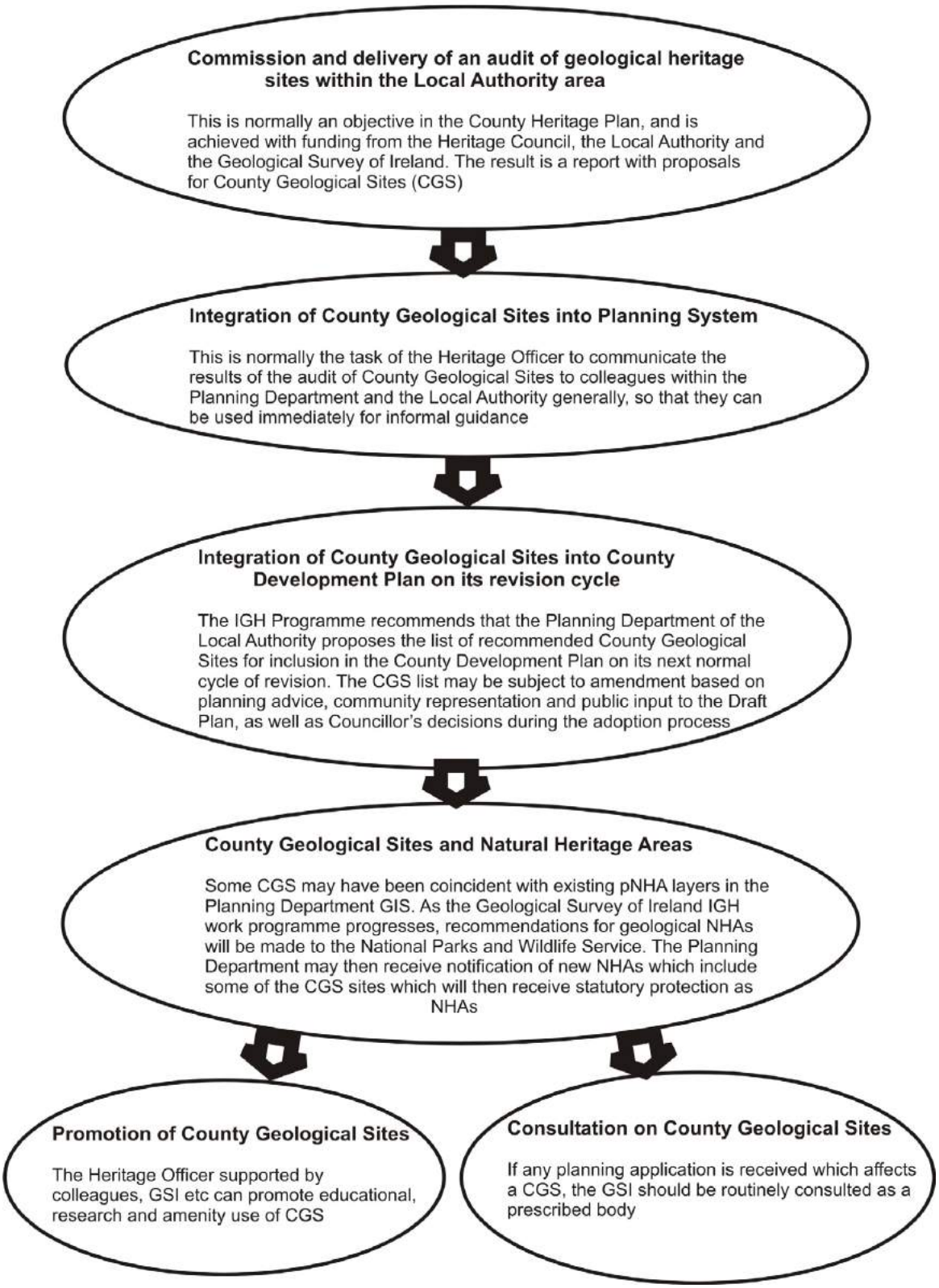
Appendix 1 – Geological heritage audits and the planning process

This appendix contains more detail on the legal framework behind geological heritage audits conducted by County Councils, and the process which operates as a partnership between the Geological Heritage and Planning Section of the GSI and the local authority Heritage Officer.

Geology is now recognised as an intrinsic component of natural heritage in three separate pieces of legislation or regulations, which empower and require various branches of Government, and statutory agencies, to consult and take due regard for conservation of geological heritage features: the Planning and Development Act 2000 [e.g. Sections 212 (1)f; Part IV, 6; First Schedule Condition 21], the Planning and Development Regulations 2001, the Wildlife (Amendment) Act 2000 (enabling Natural Heritage Areas) and the Heritage Act 1995. The Planning and Development Act 2000 and the Planning Regulations, in particular, place responsibility upon Local Authorities to ensure that geological heritage is protected. Implementation of the Heritage Act 1995, through Heritage Officers and Heritage Plans, and the National Heritage Plan 2002, allow County Geological Sites to be integrated into County Development Plans.

The chart below illustrates the essential process, established by the Irish Geological Heritage Programme in GSI, over the course of numerous county audits since 2004.

County Geological Sites - a step by step guide



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Appendix 5 – Rejected sites

A range of sites had been previously flagged for consideration in the IGH Master site list, and some were assessed as unsuitable for County Geological Site status in this audit. Similarly a range of additional sites were assessed in the audit, based on the authors' expert knowledge of Cavan's geology. It was known, for example, that caves in Cavan had not been adequately considered in the preparation of the IGH Master site list. Other sites were visited on spec during fieldwork. The rejected sites are listed below with brief notes as to why they were assessed as unsuitable for inclusion.

Lough Acanon

This site was very poorly defined on the IGH Master Site List, and its proposal may have been based on knowledge from a published paper by Phillips and Skevington from 1968. Since that time a reservoir has been created in Lough Acanon, which has enlarged the footprint of the natural lake that existed. From the map of the geology, some sections along streams into the lake have been inundated.

It is also possible that the original suggestion was a poor definition or naming of an intended site at Carrickallen Quarry, where some of the rocks in this district are well displayed. Reconnaissance fieldwork did not identify any sections of rock exposed nor any 'site' in the vicinity of Lough Acanon itself. Therefore the quarry is treated as equivalent or substitute and a site report provided.

Lough Acanon reservoir, looking north, taken from Mountain Lodge Windfarm.

Lough Keelin

No lake named 'Lough Keelin' exists in County Cavan, or indeed in Ireland. This may have been a reference to Lough Sheelin, and as the topic for which the site was listed was 'fossil shorelines', the reference may have been to the Lough Sheelin-Lough Kinale deltas which are listed as a site.

Shercock Crescentic drumlin
The Shercock Crescentic drumlin as defined and grid referenced in the IGH Master Site List is actually part of a larger ribbed moraine feature, hence cannot be defined as a drumlin.

Belturbet-Cootehill drainage pattern
This site was also poorly defined on the IGH Master Site List, and its proposal may have been based on a notional knowledge of anastomosing (haphazard) drainage in the general area around Belturbet and Cootehill. No detailed scientific research has been conducted on the drainage pattern in this area, and in a sense the drainage pattern is less an aspect of the fluvial geomorphology as to the presence of very large ribbed moraine features, which have themselves been designated a County Geological Site.

The River Erne winding through drumlin features west of Belturbet.

Lower Lough Erne
Lower Lough Erne is in County Fermanagh hence cannot be included in the Cavan IGH Audit.

Kingscourt high sulphur well
A lack of original definition or information from the IGH Master site list meant this was not traced. The Dromod Spa Well is a good alternative representative for this type of site

Ballaghdorragh Quarry
Small sulphide-bearing veins were discovered here in the 1960s as part of a mineral exploration programmes that subsequently led to discovery in neighbouring county Meath of the Oldcastle base metal deposit. This deposit, containing c. 3 million tonnes of ore (5% Zn+Pb), has not been mined. In Ballaghdorragh Quarry, narrow fractures in limestone are

filled with sphalerite, galena and barite. Despite its historic relevance in the context of mineral exploration, this site does not warrant CGS status. The quarry walls are overgrown and not readily accessible. Mineralization was not observed during the site visit. Some large boulders located beside the animal shelter on the northern side of the quarry do show thin calcite veining but without visible sulphide mineralization.

Glangevlin/Dowra

This listing (of two separate small communities) was for an example of the artesian wells of unusual chemistry in this district, under the IGH16 Hydrogeology theme. No wells were located in Dowra, and only of three near Glangevlin was located. It was far less interesting than the one of three in Swanlinbar that has been selected and reported on – Dromod Spa Well. This is the best representative of these mostly sulphurous spa wells, once taken as cures for various ailments. It is accessible, clean and maintained, and has been selected by the Geopark for an explanatory signboard.

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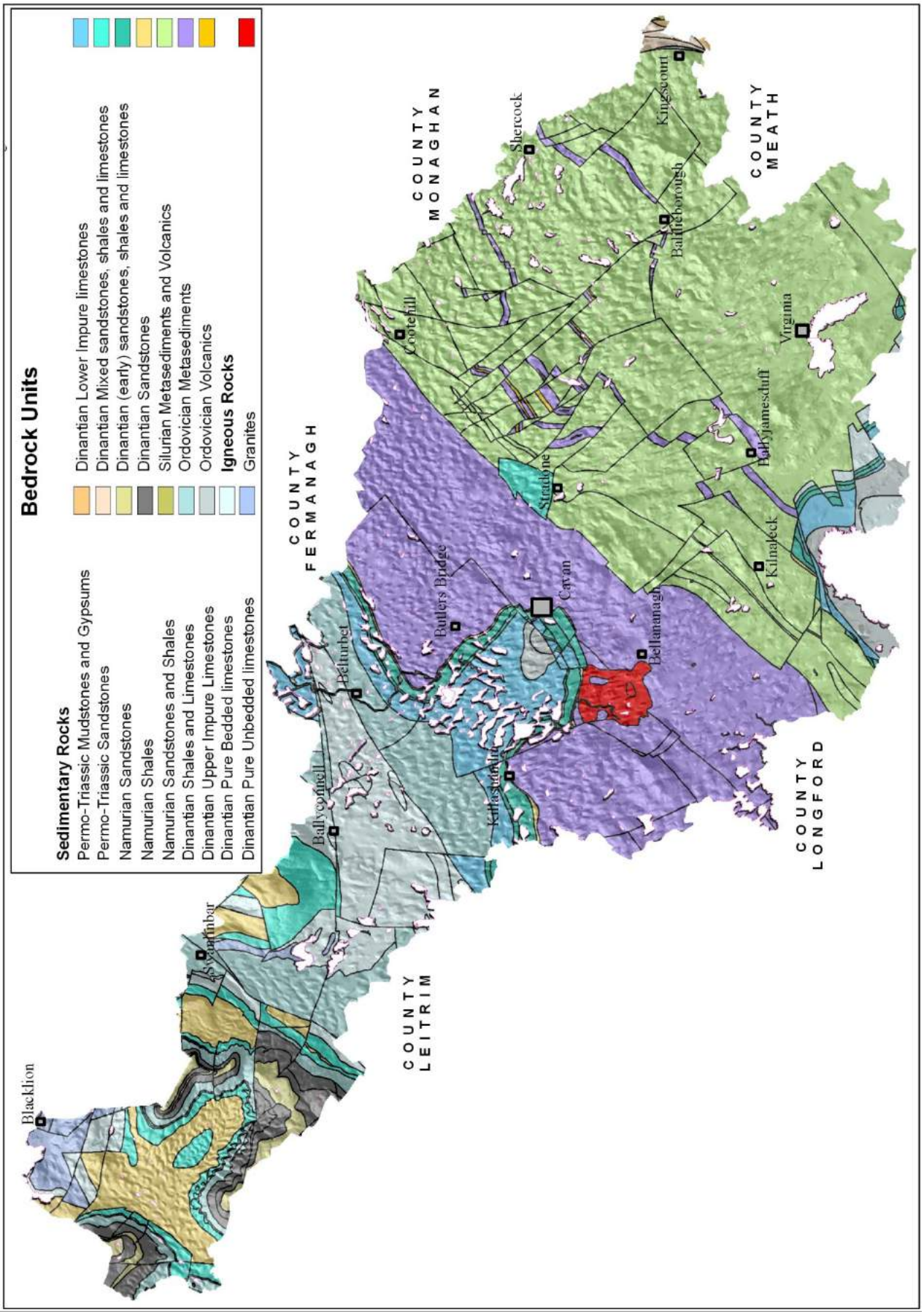
Appendix 6 - A detailed geological map of County Cavan



Appendix 7 - Geoschol leaflet on the geology of County Cavan

CAVAN

AREA OF COUNTY: 1,931 square kilometres or 745 square miles

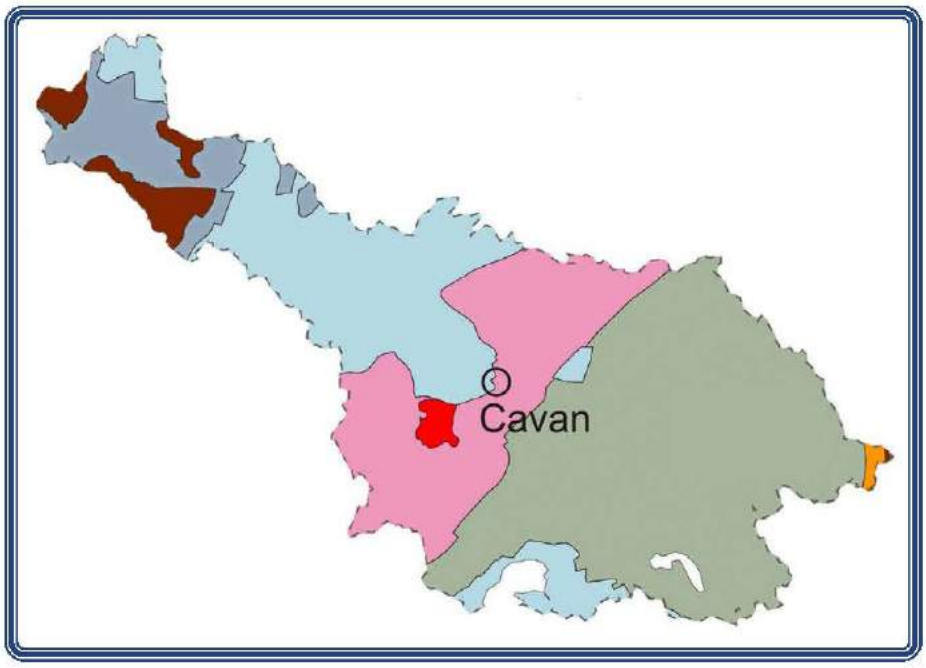
COUNTY TOWN: Cavan

OTHER TOWNS: Arvagh, Bailieborough, Ballyconnell, Ballyjamesduff, Cootehill, Kingscourt, Shercock, Virginia.

GEOLOGY HIGHLIGHTS: Drumlins, Cuilcagh Mountain Geopark, Kingscourt inlier.

AGE OF ROCKS: Ordovician - Silurian; Carboniferous - Triassic

View of Cuilcagh Mountain



Geological Map of County Cavan

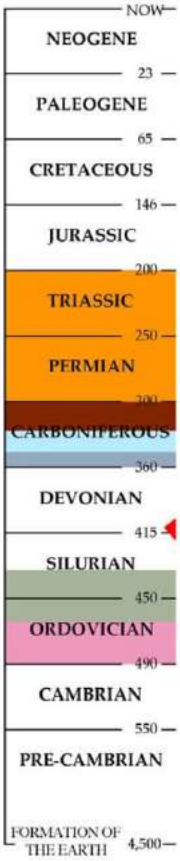
Pink: Ordovician; **Red:** Granite; **Grey:** Ordovician & Silurian; **Dark Blue:** Lower Carboniferous sandstones; **Light blue:** Lower Carboniferous limestone; **Brown:** Upper Carboniferous shales; **Orange:** Permian & Triassic sediments.

Geological history

The oldest rocks in County Cavan are 417-495 million years old [Ma] and consist of mudstones and volcanic rocks. At that time Ireland lay beneath a deep ocean, on the edge of an ancient continent made up of Scotland, north America and the north of Ireland. A huge ocean separated this continent from the rest of Ireland, England, Wales and Europe. Over millions of years, this ocean closed and the two ancient continents collided, heating and deforming the rocks to form slates. The same rock types occur from Longford, through Cavan, County Down and into the Southern Uplands of Scotland. Plate tectonic movements closed the ocean and the ocean floor rocks were faulted in slivers against the northern side. County Cavan now has these slivers of slate and sandstones stacked up across the southern half of the county. Only where a few graptolite fossils occur in the black slates can we work out the actual age and structure of the rocks.

Drumlin landscape at Farranydaly, Co. Cavan.

Drumlin and lake landscape, Cavan and Fermanagh.



Geological timescale showing age of rocks in Cavan.

As the ocean finally closed around 400 Ma bodies of molten magma moved up through the Earth's crust, cooling slowly to form granite. Just one small area of granite is known from the county, at Crossdoney a little south-west of Cavan town.

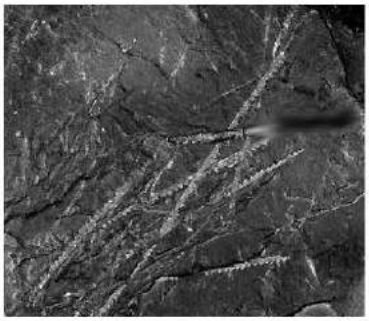
The northern half of the county is composed of Carboniferous rocks, firstly limestones deposited in a shallow tropical sea with lots of animal life. The sea then shallowed and was filled in with delta sediments which became sandstones and shales. These rocks occur in the uplands around Lough Allen and especially in the Cuilcagh Mountain area. In the surrounds of Cuilcagh Mountain, there is a lot of limestone exposed which has developed karstic features since the Ice Age, including many caves and potholes and limestone pavements.

Ireland lay in the northern tropics during the Permian and Triassic periods, and the sedimentary rocks from this time, preserved around Kingscourt in Cavan (also in Monaghan and a little in Meath), record deposition of sediments in arid deserts and temporary seas that were periodically dried out to precipitate thick evaporite deposits of gypsum. The subsequent Jurassic, Cretaceous and Tertiary periods have largely left no trace as rocks preserved on land. It is inferred that Ireland was mostly a land area, subject to weathering and erosion, which supplied only offshore basins with sediment.

However, the Cavan landscape is actually dominated by drumlins, whose international name comes from the Irish 'druim' meaning 'mound'. These are humps of debris left behind by ice sheets, and are sometimes described as a 'basket of eggs' topography. They are streamlined and show the direction of flow of the ice sheets that covered Cavan up to around 10,000 years ago.

Cavan fossils

A few localities are known in the Ordovician and Silurian rocks where graptolites (right) are found, but they are scattered. In one single locality a few trilobite specimens are known, but in general fossils are rare except for the planktonic graptolites. In Carboniferous rocks fossils may potentially be found anywhere in the limestones, but as glacial deposits often obscure the bedrock, fossils are not a highlight of Cavan.



Geoparks

The Marble Arch Caves Geopark (a recognised international status) was recently extended to include parts of Cavan, making it the first international Geopark anywhere. This recognises the importance of the geological features and the landscape around Cuilcagh Mountain, preserving them and making their interest accessible to all.

Mining & Building Stones

Whilst the Knocknacran Mine is actually just in Monaghan, the gypsum mineral it provides is mostly processed into plasterboard and other products at Kingscourt in Cavan. This mine fuelled the construction boom with plaster for construction needs and for the setting agent in cement, necessary for concrete. There are also pits extracting red mudstones to fire into bricks around Kingscourt.

Map adapted with permission from Geological Survey of Ireland 1:1,000,000 map 2003.
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Text by Matthew Parkes & Mike Simms

Section 2 - Site Reports

Site reports – general points

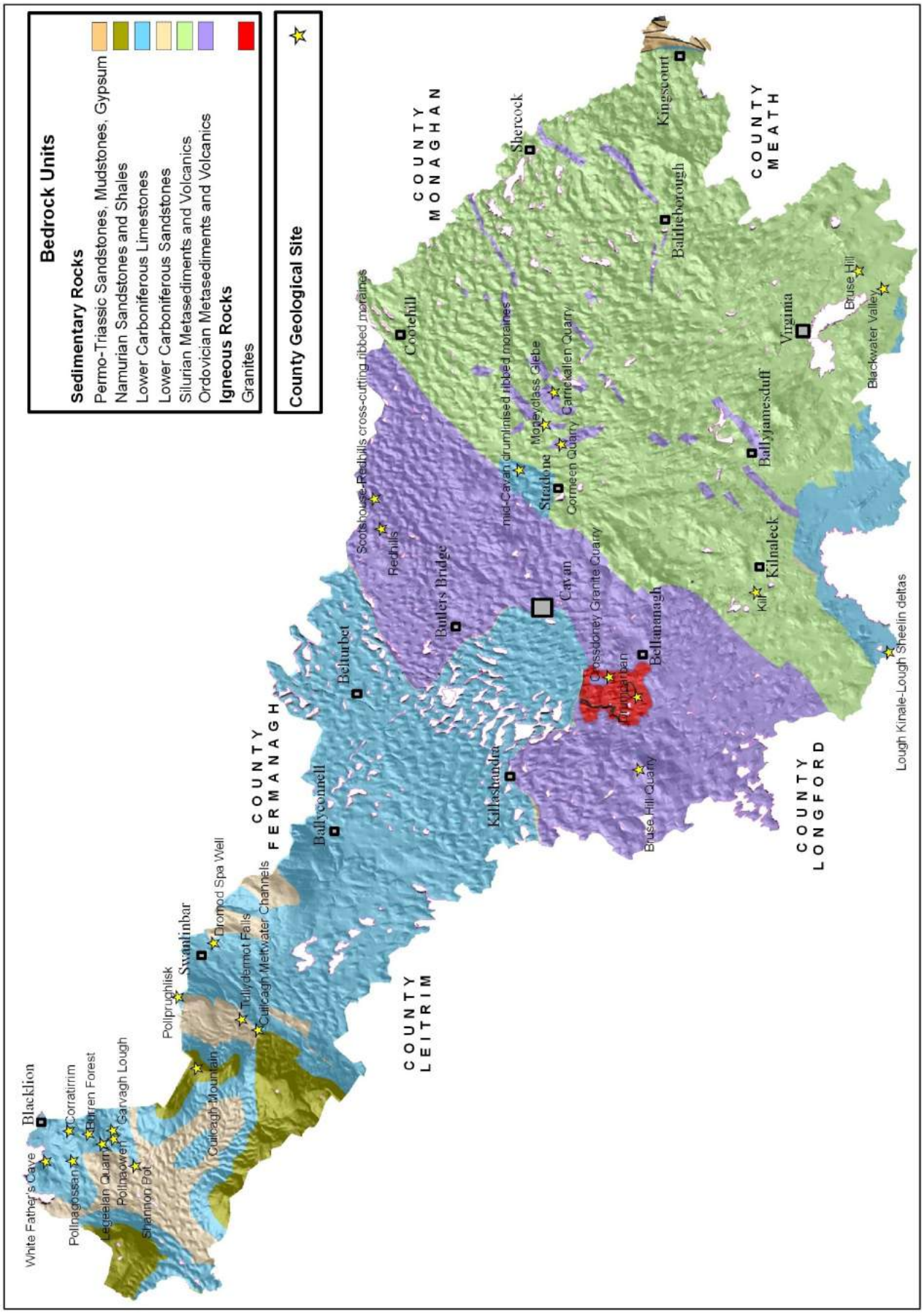
The following site reports are brief non-technical summaries of the proposed County Geological Sites for County Cavan. These have been specially prepared for this Report in order to make the information accessible to planners and others without geological training. For most sites more detailed reports and information files are held in the IGH Section in the Geological Survey of Ireland. These are available for consultation if required. Further sites may become relevant as IGH Programme work develops.

Each site report has primary location information, a mention of the main rock types and their age, and a short description of the key aspects of scientific interest. A section outlining any particular management or other issues specific to the site is included, along with one or two low resolution photographs exemplifying the site. **A CD accompanying this report will include further pictures of most sites at higher resolution, should they be required for a glossy booklet or leaflet for the general public**. Grid references are given normally for a central point in the site, if the site is small, or two extreme points at opposite ends of the site if the site is extensive or linear. They are only indicative of the location, but the site extent is best shown on the included maps. Irish Transverse Mercator (ITM), which is the geographic projection co-ordinate system for Ireland, is used to describe all site localities in each of the site reports.

A series of maps are provided with an outline of the site boundary. It is important to note that these boundaries have no legal or definitive basis. They are indicative only of the limits of exposure or of geological interest, and not based on detailed field and boundary surveys, which were outside the scope of this contract. Boundaries are drawn to include the geological or geomorphological interest of the site, but are extended to the nearest mappable boundary, such as a field boundary, stream, road or edge of forestry. On a few sites, such as in open mountain terrain, it is impractical to find a boundary within a reasonable distance and an arbitrary line may be defined. County Geological Sites are non-statutory and so this is not problematic. If any such site is assessed for NHA status in the future, such a boundary may require small revisions.

For sites that have been recommended or will be recommended for NHA designation, detailed site boundary maps will become available to the Local Authority through NPWS as the designation process is undertaken. Some areas may already be available if they are proposed NHAs (pNHA), under the Wildlife (Amendment) Act 2000. Areas which have been designated as Special Areas of Conservation (SAC) under European Habitats Directives will also have statutory boundaries already determined. The geological interest may be included within these wider areas of nature conservation.

In terms of any geological heritage site designation as NHA, due process of site reporting, boundary survey and very importantly, consultation with landowners where they can be readily identified, will take place before GSI finalises recommendations with NPWS on the most important sites to be designated. Any landowner within areas or sites identified in this report with concerns over any aspect of this project is encouraged to contact Sarah Gatley, Head of the Heritage and Planning Programme, in the Geological Survey of Ireland, Beggars Bush, Haddington Road, Dublin 4. Phone 01-6782837. Email: sarah.gatley@gsi.ie



Simplified Geological Map of Cavan with site locations indicated.